National Aeronautics and Space Administration

NASA Case Study

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TDRSS K, L: Working with a Fixed Price Contract

In the early days of the U.S. space program, the system of controlling and collecting data from low Earth-orbiting satellites included a series of ground stations scattered around the world. This worked well because the satellite population and data rates were low and signal strength was high. However, passes were short, because of the low altitude of the spacecraft. In addition, more spacecraft were coming online. More contact with the spacecraft required more ground stations. This was both a workforce problem and a political problem. Some countries were not interested in cooperating with the United States in hosting ground stations. Several critical NASA ground stations closed just before major space missions owing to political instability in host countries.

By the late 1960s, low Earth-orbiting satellites were in view of the existing ground stations only about 15 percent of the time. The proposed manned missions would require coverage that is more continuous. This would be true even if the existing ground network was augmented with the expensive space-tracking aircraft and ships used in the *Apollo* network.

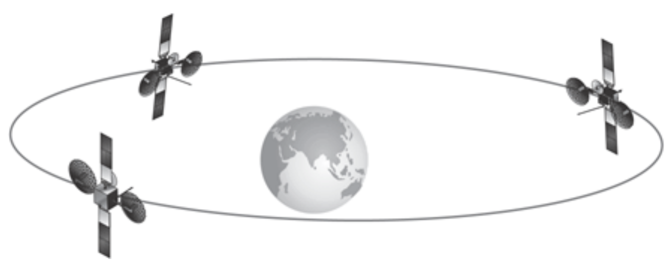

Figure 1 – TDRSS Relay

The proposed solution was to substantially increase coverage with a series of specialized geosynchronous communications satellites tracking the low Earth-orbiting satellites and relaying their data electronically to a single U.S. ground station. This concept, called the Tracking and Data Relay Satellite System (TDRSS), would provide continuous coverage, and would keep all ground-system assets on U.S. soil.

Studies continued into the early 1970s and included the successful demonstration in 1974 of the capability of the space-based tracking system. Thus, it was decided to go ahead with TDRSS. The first series consisted of six spacecraft. One was lost in the Challenger accident and was later replaced in a separate contract. Then a third series (H, I, J) was developed during the 1990s.[1] Finally, a fourth procurement (for K and L) was developed to replace some of the earliest TDRS spacecraft that had performed well beyond their design life.

The K, L Procurement Strategy

The TDRS K, L procurement started with a letter from Headquarters to the Goddard Space Flight Center (GSFC) in August 2006. What remained of the TDRS Project Office was augmented to form a team to create the RFP and associated specifications, set up the Acquisition Strategy Meeting (ASM), and to do the other functions to complete a program procurement as quickly as possible.

Figure 2 – Illustration of TDRS K/L.

The Headquarters Program Office (Space Communications and Navigation, within the Space Operations Mission Directorate) wanted the procurement to be Firm Fixed-Price (FFP), the same type of contract used for the TDRS H, I, J procurement. That was a successful contract for the government because it limited government cost exposure. Although the initial bias was for a FFP type contract, there were other factors involved in selecting this contract type. Since the H, I, J contract, the OMB[2] has imposed EVM requirements on large contracts. The government also required technical changes from the previous TDRS series such as improved communications security (COMSEC), beam forming on the ground instead of on the spacecraft, and a different launch vehicle. The contractor would also be facing some technical obsolescence problems since the last contract for TDRS was over 10 years old. The contractor raised additional concerns with an FFP contract, including,

- Reduced government oversight of development, verification, and operations of a program in FFP contracts;
- NASA's limited flexibility to influence design and requirements tradeoffs;
- The need for firm definition of all technical and programmatic requirements in the RFP.

[1] The first TDRSS Case Study (Part 1) details the story of the first three TDRSS procurements and is available on the OCKO website*: http://library.gsfc.nasa.gov/casestudies/public/GSFC-1009C-1-TDRSS.pdf*

[2] OMB Office of Management and Budget puts forth guidelines for agencies. The NASA EVM website has details at: http://evm.nasa.gov/

Boeing has informally communicated that they exceeded the original costs they expected on the TDRS H, I, J FFP contract and did not make a profit. Thus although it was a win situation for the government it may not have been a win situation for the contractor.

In the intervening years since the last contract on TDRS the Agency had started to move back from the "faster, better, cheaper" best commercial practices approach to a more government hands-on policy, with government standards and requirements for verification, processes, and procedures. This meant more oversight particularly in the Mission Assurance domain. This shift had been communicated to perspective bidders in the November 2006 RFI and in subsequent pre-RFP face-to-face discussions. According to the Boeing PM, however, this more aggressive oversight started to show up in the TDRS H, I, J development. The contractor felt the government project was too aggressive in its oversight for a contract that was FFP and supposed to be using its "best commercial practices." He said, "FP has to be a transaction at the requirements level." The government levels the requirements and allows the contractor to do the work using their best practices. The GSFC PM said,

> *"A few things are different now. H, I, J was in the 'better, faster, cheaper' era. At that time the use of government standards was frowned upon, 'Let industry do it their own way.' Even in the H, I, J era NASA management expected the Project to be managed the same as every other NASA Project in terms of rigor applied by the Project to ensure mission success. …By 2006, the lessons learned across the government spacecraft acquisition community were that it would be better to have more oversight, i.e., government standards. There was a reason for government standards--they added value. So the project was required to levy these on the contract. These standards alone (GEVS[3], GOLD Rules[4], MAR[5], etc) were not the reason for going to a FPIF [Fixed Price Incentive Fee] contract, however. One of the big drivers was that OMB now required EVM. The response to the 2006 RFI generally was that if you want EVM (cost and schedule insight) you need to have at least an FPIF contract."*

A FPIF contract with Boeing was signed December 28, 2007. General Dynamics is a subcontractor to Boeing for the ground system.

There is a cost incentive and a schedule incentive that are independent of one another. The cost incentive is reflected in the share ratio of 50/50 for cost under-runs and 70/30 for cost overruns. If the contractor comes in below the target price, the contractor gets to keep $0.50 on every dollar saved. Above the target price, the cost is shared with the government paying 70% of those costs until the Point of Total Assumption[6] (PTA) is reached. The PTA is the point on the cost line above which the seller effectively bears all of the costs of a cost overrun. That is, for each dollar of actual cost greater than the PTA the contractor's profit is decreased by one dollar.

[3] For GEVS see http://standards.gsfc.nasa.gov/gsfc-stds.html and look under STD-7000.
[4] For the GOLD Rules see http://standards.gsfc.nasa.gov/gsfc-stds.html and look at STD-1000.
[5] The MAR or Mission Assurance Requirement is a negotiated and agreed to document for each mission often including reference to numerous standards and specifications that are considered appropriate for the type of mission. For more information on the MAR see: http://sma.gsfc.nasa.gov/msd/mar.php
[6] See http://en.wikipedia.org/wiki/Point_of_total_assumption for detailed explanation of PTA.

The schedule incentive is based on an early delivery of the K spacecraft. The RFP had an eight-month schedule incentive for $1.25M per month or $10M total. Boeing accepted that incentive and signed the contract to deliver in April 2012, eight months earlier than the required Launch Readiness Date of December 2012.

Development Issues

Some issues started to show up early in the development. The Integrated Master Schedule (IMS), which is due 90 days after contract award should have been delivered in March 2008 but did not arrive until June 2008. The IMS is needed before one can do a Performance Measurement Baseline (PMB). The Integrated Baseline Review (IBR) should take place about six months after the contract is signed. At the IBR, the government and contractor do a joint assessment to verify technical content and realism of the performance budgets, i.e., the PMB. About three months of contract performance is needed prior to an IBR. Because the IMS and PMB had slipped, the IBR was rescheduled for October 2008.

The IBR did not go well. At that review, the GSFC Project Office noted a number of discrepancies in the contractor's PMB. The GSFC PM commented on the IBR:

> *"At the IBR in October 2008 they hadn't flowed down all the requirements to the lower levels and subs… We told them they didn't have a compliant baseline and they were looking for waivers which, in several cases, they had not asked for yet, or we had not approved…Several months of trying to settle on what waivers could be accepted against the original requirements ensued."*

The GSFC Systems Engineer had a similar observation:

> *"They said, 'We will be fully compliant' then they took exceptions to the GOLD Rules and asked for waivers…On the floor they assumed it was H, I, J. When we got to the IBR, they wanted to test as they tested H, I, J. We said 'No, you have to follow the K, L rules.'"*

The contractor had assumed waivers to the GSFC requirements (GEVS, GOLD rules, MAR, etc) without asking for these waivers. The net effect was an unsuccessful IBR. A delta IBR was scheduled and held in February 2009. Between the IBRs Boeing changed project managers.

Because of the challenging IBR process, the costs went up significantly. The GSFC PM indicated other factors that contributed to a cost increase from the IBR process such as an underestimation of the systems engineering work, higher costs from subcontractors and in-house groups, and greater parts obsolescence than anticipated. Everyone agreed this had been a problem. The Boeing PM reflected:

> *"The most challenging aspect of the program has been the design obsolescence of H, I, J which is ten years old….Value is placed on heritage so there is value in proposing what has flown before. Design obsolescence was expected but the magnitude was a surprise."*

Aside from the significant parts obsolescence cost increase, the major driver for the increased cost from the first IBR to the Delta IBR appeared to be the requirements that did not make it into the baseline and the pushback from the implementing groups at Boeing and the subcontractors on the budgets allocated to do this work. The GSFC PM commented:

> *"At the start the contractor, who was the incumbent from H, I, J, planned to greatly leverage H, I, J heritage. They had overestimated their ability to reuse old designs and parts. Also, they seemed to get pushback from their in-house groups as well as contractors on cost."*

It appeared that the requirements from the GEVS, GOLD rules, MAR, etc were not completely flowed down to all these. This could have been due to an assumption by the contractor that waivers could and would be granted to these documents. While tailoring of these documents is possible it should not have been assumed a priori that waivers would be automatically provided. The Boeing PM reflected:

> *"Boeing thought that tailoring would be more acceptable [than it was]. In trying to get an advantage in the proposal, we assumed we could get GEVS, GOLD Rules and some aspects of the MAR tailored. We weren't aware how difficult it would be to tailor those documents. It is a long time between contracts."*

It is also true that circumstances change dramatically over time in the hi-tech space industry. Trying to compete on a FP contract is a challenge because of these changes. The Boeing PM thought that a Cost Plus (CP) contract might have been more appropriate for this type of program. The Boeing PM had some thoughts on this subject:

> *"H, I, J were built to best commercial practices. Our best commercial practices today are different, more stringent-a good thing-they make for a more robust and reliable spacecraft. So in this sense complying with the spirit of the GEVS, for example, was not difficult. But our rules are different from GEVS and relating them to GEVS is tough… An example of the above is the hi-rel parts. NASA has an EEE standard for hi-rel parts that is different than the MIL STD 1547 used by the DoD. It is also different from the Boeing standard. So figuring out ways to test and qualify hi-rel parts one is faced with three different systems for doing this and compliance becomes a challenge."*

The GSFC PM acknowledged that and agreed that there was probably more non-recurring engineering on this program than most would have expected, but observed that the non-recurring on the K/L program was significantly less than the H,I,J program, which was Firm Fixed Price and was fundamentally a new design.

> *"The use of FP on any program where there is substantial non-recurring design effort needs to be well-considered… FP goes against our culture to some extent, with ongoing incorporation of lessons learned, for instance… NASA engineers are raised in a culture to bring technical expertise to the table and struggle in the FP environment not to use their training and experience to make things better."*

The Boeing PM said that the relationship between the two teams has been good from the project level down through all the peer-to-peer relationships. He said, however, "If the contract went more toward FP it would probably get worse; if it went more toward CP it would get better." The GSFC PM commented, "Part of the problem is our technical people struggle to understand how to engage [with the contractor] in this contractual environment."

Looking back, the Boeing Project Manager (PM) reflected on FP contracts:

> *"I don't believe the GSFC and the Agency culture are suitable for FP contracts. They have a highly technical culture, responsible for the success of the mission down to the finest detail. FP has to be a transaction at the requirements level. The contractor not only has to convince itself but also has to convince the GSFC community… All this is not bad but it is difficult to quantify the cost and schedule of what it takes to convince the GSFC community of the adequacy of any design solution. As a result there is a high risk of cost and schedule overruns."*

Timeline

#	Contract Event	Launch Event	Dates
1	RFP issued for design of TDRSS (2-year study)		May 1971
2	NASA Administrator requests Congress to fund the TDRSS program as a way to save money		September 1973
3	Phase I studies complete on design by WU and RCA		January 15, 1976
4	Contract for A-F awarded to Western Union (Spacecom) $786m for the prime contract		December 12, 1976
5	Preliminary studies begin for advanced TDRSS (TDAS)		1981
6		Launch of A (TDRS 1)	April 4, 1983
7		Loss of B (TDRS 2) in Challenger accident	January 28, 1986
8	Replacement contract for B start date (DPAF) TRW for $448m		July 1986
9	Phase A studies done for Advanced TDRSS		1987-89
10		Launch of C (TDRS 3)	September 29, 1988
11		Launch of D (TDRS 4)	March 13, 1989
12	Phase B studies done for Advanced TDRSS		1989-1992
13	Contract reformed: NASA takes ownership of TDRSS S/C		July 1, 1990
14		Launch of E (TDRS 5)	August 2, 1991
15		Launch of F (TDRS 6)	January 13, 1993
16	Award of H-I-J contract to Hughes for $486m		February 23, 1995
17	NASA delays launch of TDRS G for 3 years (from 1992) due to extended life of TDRS 1	Launch of G (TDRS 7) Replacement for B	July 13, 1995
18		Launch of H (TDRS 8)	June 30, 2000
19		Launch of I (TDRS 9)	March 8, 2002
20		Launch of J (TDRS 10)	December 4, 2002
21	Contract for K-L signed with Boeing for $618-725m		December 28, 2007
22		Launch of TDRS K	Planned for 2012
23		Launch of TDRS L	Planned for 2013